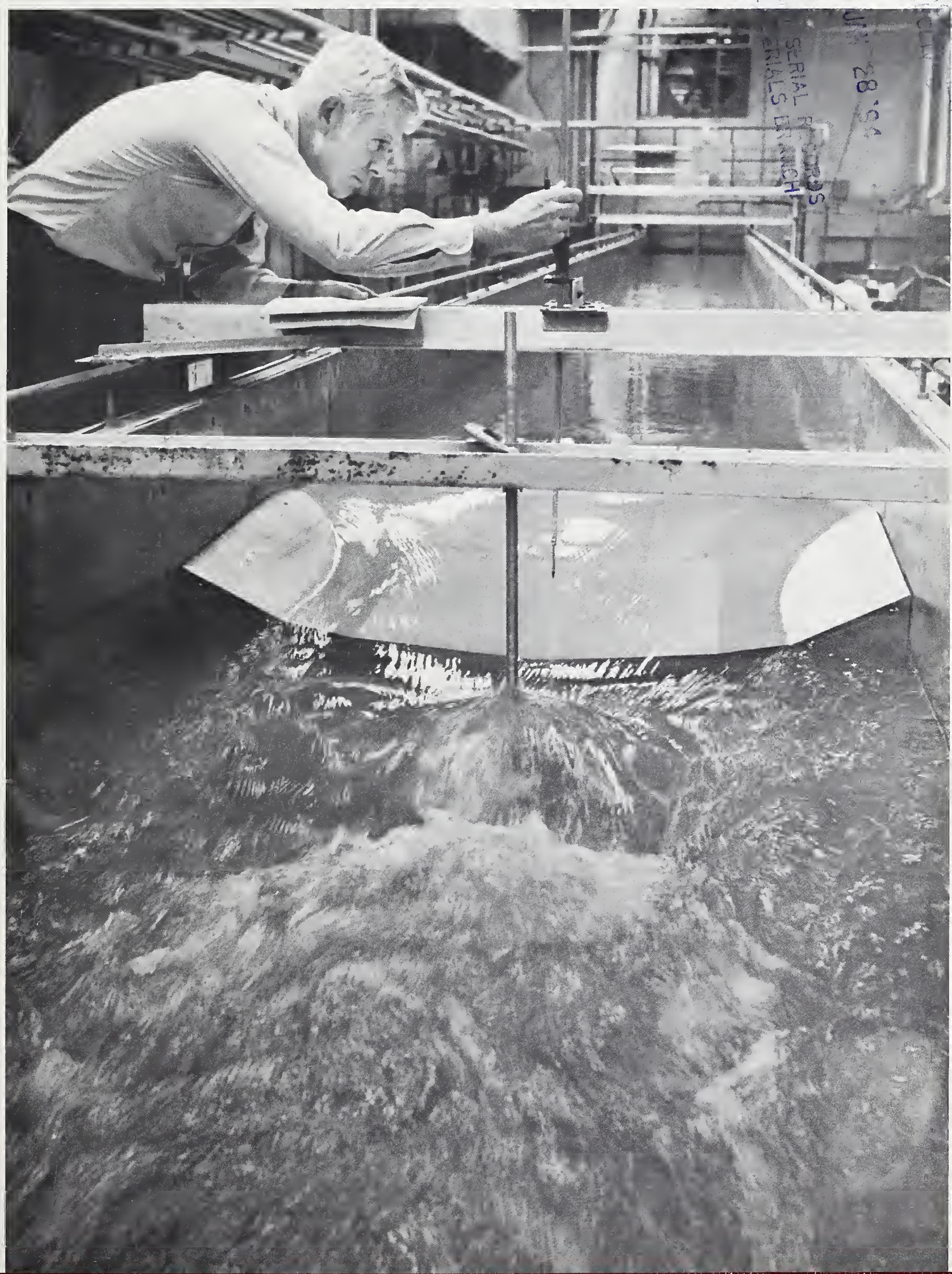
U.S. Department of Agriculture Agricultural Research Service
June 1983

Agricultural Research



Watershed Management—A Conservation Priority

We all live on watersheds. Our yards and neighborhoods are watersheds. So are our cities and towns. Yet, for many of us, watersheds are perceived as a part of the countryside—the valleys and lakes where water collects.

No matter what we do to a watershed—build houses and factories on it, farm it, mine it, harvest timber from it—we disturb it, affecting both the quality and amount of water it produces.

Watersheds are so vital to the future productivity of our farmlands and rangelands that ARS spends about $13 million each year to develop technologies to protect them.

ARS research is concerned with preserving the quality and quantity of water and soil, with controlling the amount of sediment that enters lakes and reservoirs, and with determining how land use, farming operations, and conservation practices affect downstream water supplies.

Eight major watershed research centers located in different physiological regions contribute to the ARS national effort.

One of ARS's watershed research objectives is to find out how and where soil is eroded and deposited and how these processes affect soil productivity and water quality.

The ARS watershed program is also concerned with improving the design of hydraulic structures. Of primary concern is the safety of these structures. Other research interests include improving water quality by increasing the efficiency with which sediments and associated chemicals are trapped, and controlling the stability of river banks and channels using vegetation and inexpensive grade control structures.

At several centers, ARS scientists are studying nature's own self-cleaning mechanisms, such as the removal of suspended sediments from reservoirs by algal blooms, and the effectiveness of trees and grasses as natural filters for removing plant nutrients before they can enter surface waters.

Fertilizers, pesticides, and other potential water contaminants frequently become attached to and move with the sediments that erode from croplands. Water soluble contaminants are more troublesome because they can move into groundwater undetected.

At the Taylor Creek/Nubbin Slough (TCNS), Fla., a dairy-intensive watershed, ARS scientists have been monitoring water quality since 1972. Here sediment is not a problem. However, stream nutrient concentrations from animal wastes are among the highest in the United States.

The TCNS drainage basin lies within Okeechobee County north of Lake Okeechobee. Although the watershed supplies only about 5 percent of the lake's total water, it contributes 28 percent of the total phosphorus and 6 percent of the total nitrogen to the lake. This natural reservoir is used for irrigation and for water supply to the Everglades. It also functions as an essential body of water stabilizing the shallow Biscayne aquifer of southeast Florida and helping prevent saltwater from entering the water supply. TCNS is not only the direct water supply for the small cities around it, but it also is the final backup water supply for the more than 5 million residents of southeast Florida.

Soil scientist L. Hartwell Allen, Jr., found that soils and sites play major roles in stream quality, a continuing problem. Studies by Allen and other researchers have substantiated that high concentrations of phosphorous and nitrogen are associated with dairy farming along creeks and Nubbin Slough tributaries. The high salinity levels that were observed are associated with the return flows from citrus irrigation.

A technical advisory committee, composed of representatives of several State and Federal agencies, including ARS, identified sources of phosphorus and nitrogen. Point sources were wastewater systems in and around dairy operations. One major nonpoint source was attributed to dairy cattle that lounge in waterways to find relief from the heat. Other nonpoint sources included runoff from cattle-holding areas, barns, and pastures.

The technical advisory committee helped initiate the Taylor Creek Headwater Project to determine the baseline water quality and nutrient loads. The committee also developed and implemented a water quality plan for cost-sharing (with State funds) best management practices (BMP's) with landowners. The Soil Conservation Service helped design the BMP's. The committee then evaluated the effectiveness of these practices in lessening high nutrient loads.

Among several approved BMP's are—

- Fencing cattle away from streams while providing shade structures, watering facilities, and cattle stream crossings;
- Land smoothing to fill shallow ditches and to promote uniform overland waterflow across pastures, and strips of vegetation.

Two BMP's suggested by ARS researchers:

- Using materials, such as clay minerals or limestone, in lagoons and biological detention systems to adsorb or otherwise immobilize soluble phosphorus.
- Selecting sites of future dairies on the better drained, deeper watertable soils, with low slopes away from water channels.

In 1981, a $1.3 million Rural Clean Water Program project was approved by the Federal Government for TCNS, based largely on ARS research results documenting the severity of the water-quality problem.

The TCNS watershed project exemplifies the enormous investment of human and financial resources needed to develop improved techniques for assessing and predicting water supplies and their quality. ARS watershed research is long-term, costly, labor-intensive, vital research aimed at harnessing our Nation's water resources for the benefit of society. As stated in the new Program Plan, ARS has committed the resources needed to better understand the various components of the hydrologic cycle—rainfall, evapotranspiration, and groundwater and surface water movement—to develop and evaluate improved technologies for use by action and regulatory agencies. In so doing, ARS helps ensure that future generations will inherit watersheds that are still stable, safe, and productive.

Terry B. Kinney, Jr.
Administrator, ARS

Contents

Agricultural Research
Vol. 31 No. 12
June 1983

Editor: Jean M. Rawson
Acting Assistant Editor: Joan Blake
Photography Editor: Robert C. Bjork
Art Director: Deborah Shelton
Circulation Manager: Charles Jones

Agricultural Research is published 10 times per year by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, D.C. 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through March 31, 1987. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by month and photo number.

Magazine inquiries should be addressed to: The Editor, Information Staff, Room 318, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, Md. 20705. Telephone: (301) 344-3280. When writing to request mailing list changes or deletions, please include a recent address label.

John R. Block, Secretary
U.S. Department of Agriculture

Orville G. Bentley
Assistant Secretary
Science and Education

Terry B. Kinney, Jr.
Administrator
Agricultural Research Service

Cover: At the USDA Sedimentation Lab, Oxford, Miss., ARS hydraulic engineer Joe C. Willis experiments with a model of a critical-flow measuring structure that is actually in use in a Mississippi creek. These experiments determine how water and sediment move through, and help to improve field measurement accuracy. Article begins on p. 8. (0583X502-14)

Science and Our Resource Heritage

Tracking Sources of Water Pollutants 4

Separating "natural" from man-made sources of chemical pollutants is confusing, but a must for planning control programs.

Sedimentation – A Threat to Clean Water and Fertile Soils 8

Scientists in the South and West approach the question of how to keep soil on the land and out of the water.

Putting Down Roots 10

Plants take tests to see which can best keep a streambank from crumbling into the stream.

Remaking the Good Earth 12

Research around the country tackles the special problems of reclaiming stripmines for agricultural use.

Livestock and Veterinary Sciences

Feed Costs Vary for Crossbred Cows 7

The genetic potential for size and milk production affects a crossbred cow's profitability when raised for meat.

Postharvest Science and Technology

Starter Culture for Processed Meats 7

Summer sausages could benefit from a healthy measure of culture, and always be in good taste.

Crop Sciences

The Speedy *Rhizobium* from China 6

Fast-growing bacteria collected in China are a boon to scientists studying nitrogen fixation.

Cranberry Girdlers Eat Trees, Too 14

The root weevil is exonerated and the cranberry girdler implicated as the perpetrator of major damage to Douglas fir seedlings.

Agrisearch Notes

Pesticide Runoff Study Completed 15
Another Nematode is Found 15
Ozone Tolerance of Pines 16

Tracking Sources of Water Pollutants

One of nature's sources of free nitrogen. (037-13-35)

Nature has a way of confounding scientists who are charged with tracking sources of man-made chemicals in runoff waters and searching for ways to minimize pollution of U.S. streams, lakes and underground water.

Nature generates some of the free nitrogen in the atmosphere by releasing thunderous bolts of lightning. Rainfall then carries this soluble nitrogen to the earth and into bodies of water.

Nature stimulates microorganisms to break down residues on croplands, pastures and woodlands and release chemical nutrients that often find their way into the atmosphere, streams, and groundwater.

This natural system is beneficial in that it recycles nutrients that nurture crops and add to bountiful harvests. But, in so doing, it complicates the lives of those research investigators who must track, as part of this Nation's Clean Water Act, wayward nutrients turned water polluters: soluble nitrogen is soluble nitrogen whether it comes from misused nitrate fertilizer, from decomposed plant residues and animal waste, or by way of lightning and rain.

Studying nature's contribution to nitrogen pollution nearly a decade ago, two ARS soil scientists found that nitrogen received in rainfall is equal to about two-thirds of the soluble nitrogen in surface runoff from normally fertilized cropland.

Soil scientists Gerald E. Schuman and Robert E. Burwell, in cooperation with University of Nebraska and Iowa State University, learned that rainfall at Treynor, Iowa, contributed an average of 6.47 lb of nitrogen per acre each year in an area where annual precipitation is about 30 inches.

Nitrogen from the atmosphere was equal to about two-thirds that of the soluble nitrogen in runoff from a watershed planted to corn and fertilized at the recommended rate of 150 lb of nitrogen per acre. On an adjacent watershed, fertilized at 2-1/2 times the recommended rate, rainfall was equal to about one-half that of the soluble nitrogen measured in runoff.

Studies at Treynor indicate that nature's ways can be modified, however. Scientists compared the effectiveness of terracing and contour farming in restricting runoff from cropland fertilized at 2-1/2 times the recommended nitrogen rate. Only a twelfth as much total nitrogen was lost in runoff from the terraced watershed as from one that was contour-farmed.

Chemicals from the natural biosphere have been studied at six Iowa locations—Ames, Boone, Charles City, Creaton, Eldora, and Guthrie Center. J.M. Laflen, ARS agricultural engineer, and M. A. Tabatabai, Iowa State University agronomist, measured chemical elements in precipitation falling at the six locations during a 27-month period.

In their studies they emphasized nitrogen (in ammonium and nitrate forms) and sulfur (as sulfate), primarily because nitrogen can pollute water resources and cause undesirable algal growth, and some forms of sulfur can cause acid rain. Acid rain can lead to increased leaching of calcium from soils, deterioration of aquatic ecosystems, and damage to buildings.

Laflen and Tabatabai found that precipitation delivered 11.1 lb of nitrogen and 14.3 lb of sulfur on the average per acre at the six locations annually. This added nitrogen aids plant growth, as does sulfur in Iowa, where soils have a low reserve of that element in the form available to plants. Their coming from the atmosphere, however, makes them difficult to track and impossible to control as water pollutants. Fortunately for Iowans, most of the samples of rain proved slightly alkaline, not acid.

The actions of nature also proved perplexing in runoff studies on pastures at the U.S. Meat Animal Research Center, Clay Center, Nebr. Results of 3-year studies by ARS soil scientist James S. Schepers in 1978-80 cause him to wonder if it is possible to identify a specific source of nonpoint pollution from Great Plains pastures.

Schepers, working in cooperation with the University of Nebraska, found that the load of chemical pollutants in runoff after a storm was, as expected, higher when pasture was stocked with livestock than when cattle had been removed or rotated off. Unexpectedly, however, he found that pastureland where cattle were excluded for 3 years carried a still higher concentration of pollutants, probably because of wildlife activity and plant decomposition.

Schepers learned that no one rainfall or runoff characteristic can be used to predict all chemical constituents in runoff waters from Nebraska pastures. For example, rainfall frequently contained higher concentrations of soluble nitrogen than the pasture runoff, which demonstrates soil's ability to remove chemicals by the processes of infiltration and adsorption. It also demonstrates that nature can be very unpredictable.

More unpredictability was found to the east, near Coshocton, Ohio, where, in studies by soil scientist Lloyd B. Owens, a 45-acre unpastured woodlot yielded more nitrate in runoff than a nearby 64-acre pasture stocked with 17 cows.

Owens measured nitrate in runoff into streams from an unstocked pasture for 2 years, and from the same pasture stocked with 17 cows during the following 3 summer grazing periods, and compared the results. He also measured nitrate from the woodlot. Both the pasture and wooded watersheds contained spring-fed streams.

The average concentration of nitrate from the ungrazed pasture was 0.5 ppm of runoff water; from the grazed pasture, 0.7 ppm; and from the woodlot, 1.2 ppm. The U.S. Public Health Service says water is safe to drink up to 10 ppm of nitrate-nitrogen. Owens also measured potassium, phosphorus, calcium, magnesium, sodium, sulfur, chloride, and other potential pollutants. Their concentrations were similar to those from the woodlot and only slightly higher when cattle were on pasture.

Nitrate pollution also can reach groundwater stores through soil absorption and percolation. In studies funded by the Nebraska Water Resource Center, soil scientist Gary W. Hergert, University of Nebraska, found nitrate losses of 30 to 40 pounds an acre below the corn root zone on irrigated sandy soils at Tryon in west central Nebraska. Although he says this may not be typical of all sandhill-area soils, such losses can occur even with good fertilizer management and irrigation scheduling.

In runoff studies on pastures such as this at the U.S. Meat Animal Research Center, Clay Center, Nebr., researchers found that even when cattle were excluded for 3 years, wildlife activity and plant decomposition caused still higher pollutant concentration in streams. (0676X688-26)

Level bench terraces near Mandan, N. Dak. Comparative studies have determined that terracing is much more effective than contour farming in restricting nitrogen runoff. (ND-818)

The corn field had been fertilized and irrigated for 6 years, and at the time of the study, Hergert found nitrate-nitrogen to a depth of 50 feet at a location where the water table varies from 90 to 100 feet below the surface. He believes these subsurface nitrates were caused in part by commercial nitrogen fertilizer and irrigation water.

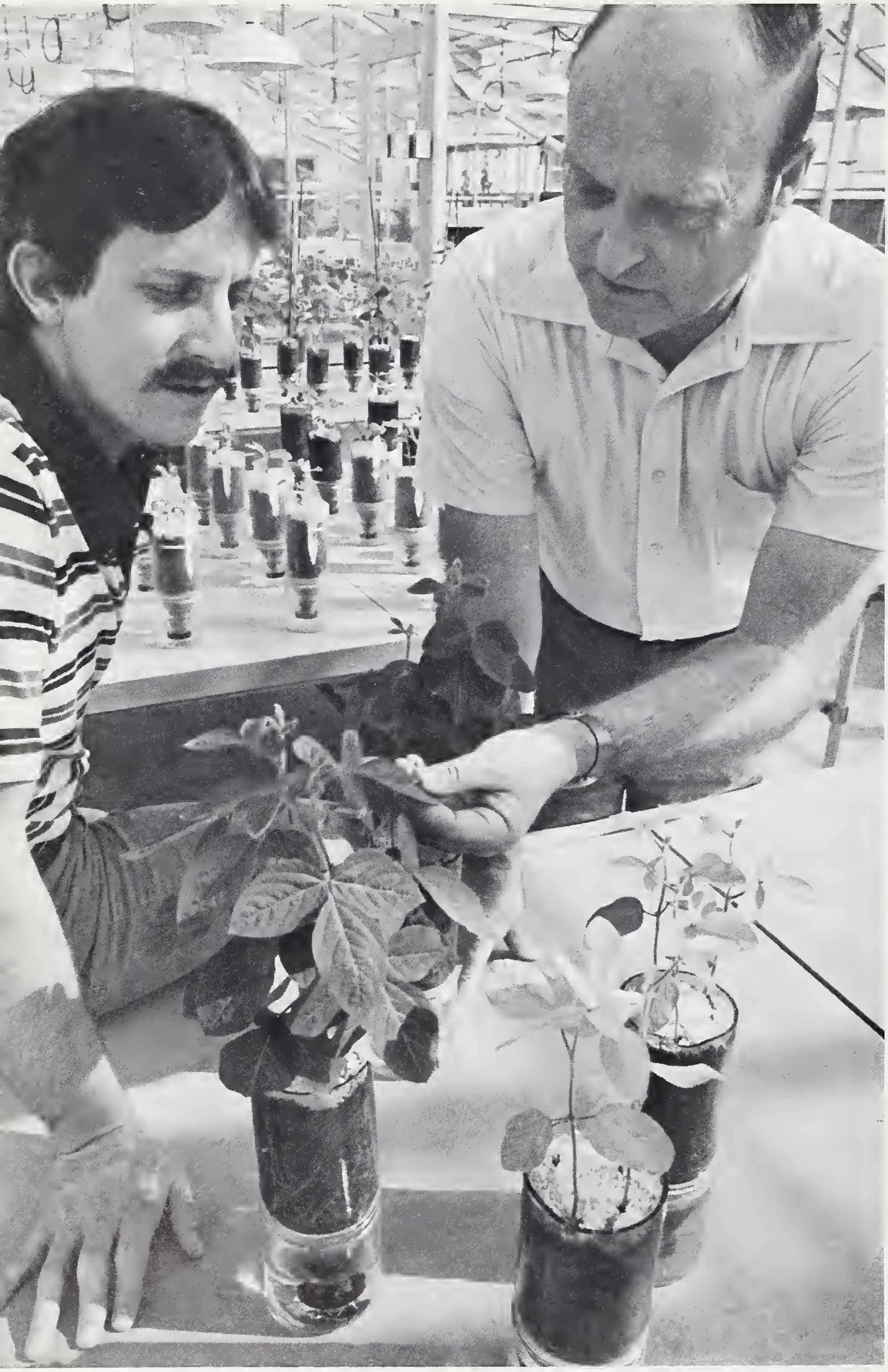
Harvested crops recover, on the average, only about 36 percent of the nitrogen added to the soil as fertilizer and in crop residues, manure, and organic wastes, says ARS soil scientist James F. Power, Lincoln, Nebr. Power is participating in studies to determine tillage and fertilizer practices that promote more efficient utilization of nitrogen by crops, while minimizing the potential for damage to the environment. The studies, which began in 1980, are being done under cooperative agreements with the Universities of Illinois, Kentucky, and Nebraska.

Power says that soil microorganisms immobilize some of the applied nitrogen in a form not immediately available to plants, or cause the release of nitrogen to the air. And some nitrogen may leach below the plant root zone to ground water as a potential pollutant of streams and lakes.

Making plants use nitrogen more efficiently will, besides minimizing pollution potential, save energy used in producing nitrogen fertilizer, help restrict farmers' rising production costs, and help growers adapt to nature's sometimes confounding ways.

—(By Robert E. Enlow, Peoria, Ill.) ■

The Speedy *Rhizobium* from China



Microbiologists Harold H. Keyser (left) and Deane F. Weber observe lush foliage on 'Peking,' a Chinese soybean variety inoculated with the fast-growing strain of Chinese *Rhizobium*. American 'Lee' soybean plants (right) inoculated with the same strain of *Rhizobium* are yellowed—an indication of poor root nodulation. (0383X216-13A)

A fast-growing bacterium from the roots of Chinese soybeans may be as important to scientists studying nitrogen-fixation as *E. coli* is to genetic engineers.

Soybeans collected in China have yielded *Rhizobium* bacteria that grow at a rate three times faster than those found in the United States, says microbiologist Harold Keyser. Genetics studies on these important bacteria will proceed more quickly because of their rapid growth rate.

These nitrogen-fixing bacteria are ineffective on the soybean varieties commonly grown in the United States. However, they could be indirectly useful to U.S. growers if their fast-growing trait could be added to strains of commercial U.S. soybean *Rhizobium* through genetic engineering. Companies could then produce *Rhizobium* for soybean growers faster and more economically, says Keyser.

Rhizobium bacteria contribute about $1 billion worth of nitrogen fertilizer each year to the soybean industry in this country, according to microbiologist Deane F. Weber.

Soybean seeds are routinely coated with strains of U.S. soybean *Rhizobium* during planting. The bacteria invade the developing plant's roots, causing the roots at that point to swell into round nodules. The bacteria in the nodules take free nitrogen from the air and manufacture nitrogen-containing protein for the soybean plant. In exchange, the plant supplies nutrients for the bacteria to grow on. Approximately 30 percent of the nitrogen in soybean protein comes from nitrogen fixation by *Rhizobium*. The percentage would be higher if soil nitrogen levels were lower, says Weber.

Expeditions to China during 1978 and 1979 added many new *Rhizobium* strains to the collection at the Beltsville Agricultural Research Center. In 1980, others were brought in by Tsi Seng Hu, who was sent by the People's Republic of China to work in the Cell

A comparison of 'Lee' and 'Peking' root development shows the effects of the Chinese *Rhizobium* on each variety. 'Peking' (right) exhibits larger roots and superior nodulation. (0383X216-25A)

Culture and Nitrogen Fixation Laboratory. Eleven of the 60-odd *Rhizobium* strains from China proved to be fast growers, according to Keyser.

"At first, we assumed that these bacteria were not soybean *Rhizobium*," Keyser says. Their fast growth and chemical reactions made them appear to be another type of *Rhizobium*. But when the bacteria formed nodules with several soybean varieties, we knew that they really were unusual soybean *Rhizobium*. Keyser collaborated with B. Ben Bohlool, at the University of Hawaii, Hu, from the People's Republic of China, and Weber at the Beltsville Agricultural Research Center.

Although the bacteria produced nodules on the roots of many soybean varieties, the only nodules that effectively fixed nitrogen were those formed on Peking—a Chinese soybean variety that is one of the ancestors of many American varieties, says Weber.

Harold H. Keyser and Deane F. Weber are located in Bldg. 011A, Rm. 116, Beltsville Agricultural Research Center-West, Beltsville, Md. 20705.—(By Ellen Mika, Beltsville, Md.) ■

Starter Culture for Processed Meats

Fermented meat products produced by adding starter cultures are safer and have more consistent flavor and texture than meat products made without added culture.

Studies by James L. Smith, research microbiologist at the Eastern Regional Research Center (ERRC), Philadelphia, Pa., have shown that starter cultures—like those used in yogurt and cheeses—stimulate faster and more consistent fermentation. This reduces the chance for growth of dangerous food poisoning bacteria such as *Salmonella, Clostridium botulinum* and *Staphylococcus aureus*.

During processing, pepperoni, Genoa, Thuringer, and other summer sausages depend on bacteria to produce lactic acid, which develops the meat's taste and texture, lengthens shelf life, and protects against contaminants.

However, Smith says that "many meat processors use a technique called 'natural fermentation.' They depend on chance contamination of the sausage mix by wild lactic acid bacteria." Fewer than half of U.S. meat processors actually add bacterial starter culture to fermented meats, he says.

When desirable microorganisms are present, high-quality sausages are manufactured. If other bacteria dominate, however, fermentation could produce off-flavors or a gas that bursts the sausage casing. In very rare situations, growth of a pathogen could lead to disease or food poisoning.

"Meat processors can obtain safer sausages with more consistent quality by using known starter cultures in their production lines," Smith says. "The products' greater acceptability will benefit both consumers and industry."

James L. Smith is located at the Food Safety Laboratory, Eastern Regional Research Center, 600 E. Mermaid La., Philadelphia, Pa. 19118—(By Andrew Walker, Beltsville, Md.) ■

Feed Costs Vary for Crossbred Cows

Average weaning weights of calves from a group of large and high milk-producing crossbred cows exceeded weights from another group of cows by 40 pounds. But at slaughter time—455 days of age—the lighter group of calves exceeded the heavier group in pounds of retail meat per unit of feed consumed by cow and calf.

This continuing study at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebr., indicates that feed energy costs for maintaining beef cows may have as important an influence on profits as the amount of beef produced per cow.

Chemist Calvin L. Ferrell and animal geneticist Thomas G. Jenkins observed that energy requirements of cows differ according to their genetic potential for mature size and milk production. The crossbreds compared were Angus-Hereford or Hereford-Angus, medium milk-medium size; Charolais-Angus or Charolais-Hereford, medium milk-large size; Jersey-Angus or Jersey-Hereford, high milk-medium size; and Simmental-Angus or Simmental-Hereford, high milk-large size.

"Our study shows that cows with high milk production potential have higher maintenance requirements per unit of body weight than cows with low milk production potential," says Ferrell.

The medium milk-medium size crossbreds most efficiently converted feed energy into retail meat.

Looking at the data from the standpoint of feed energy rather than economics, Ferrell says, crossbreds characterized by high milk production and large mature size potentials may require high maintenance overhead that is not offset by greater production.

The researchers stop short of saying that one kind of crossbred cattle is best for all production and marketing situations. Rather, they suggest that matching the cattle breed type with the resources available could be the most efficient management strategy.

Calvin L. Ferrell and Thomas G. Jenkins are located at the Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, Nebr. 68933.—(By Ben Hardin, Peoria, Ill.) ■

Sedimentation— A Threat to Clean Water and Fertile Soils

Stream erosion and sediment deposition in a creek in Washington State. (WA-90-522)

Top: Time-lapse photograph of a laser beam helping to level land in Arizona. The laser source mounted on a tripod sends out a beam that regulates the height of a drag scraper pulled behind a tractor. "Dead-level" fields help reduce salt-producing runoff from irrigation. ARS scientists at Grand Junction, Colo., are using identical equipment in their irrigation studies. (PN-4132)

Above: Agricultural engineer Harold R. Duke inspects a battery-operated timer that automatically turns an irrigation control valve off and on at specified intervals. Precise and automatic water control can prevent sediment losses in runoff. (0981X1109-27A)

Sedimentation, believed by many authorities to be our most serious water pollution problem, is of considerable economic concern. This is especially true in those areas where sediment deposition is high, such as in the Southern and Western United States.

Large quantities of sediment can permanently damage agricultural lands, partly or completely fill stream or irrigation channels, destroy the spawning grounds of fish, and shorten the lifespans of reservoirs.

Controlling or reducing soil erosion, sediment transport, sediment deposition, and farm chemical runoff is essential to conserving the Nation's high-yielding soil and clean water.

In one example of ARS research efforts to solve sedimentation problems in the West, scientists are working to reduce the estimated 585,000 to 720,000 tons of salt being contributed annually by the Grand Valley to the Colorado River (see *Agricultural Research,* July-Aug. 1982, p. 11). Researchers are examining "dead level" irrigation basins created with laser-controlled land leveling machinery, and several approaches to automated, timed pipeline and surface irrigation systems.

Other ARS research in Colorado is addressing the problem of salts, such as calcium and magnesium sulphate, which are released when water filters through material that has been fractured by the massive earth-moving operations required to extract coal or uranium. Researchers have found a better way to predict how much salt will be leached from stripmined areas before mining begins by analyzing drill samples (see *Agricultural Research*, April 1983, p. 15). Applications for surface mining permits can now be much more accurate than before in the information they contain on potential salt pollution of groundwater and streams.

The impact of agricultural practices in the West is another important research area. ARS and Colorado State University have received a 5-year, $1.9 million grant from the National Science Foundation to study the changes that are occurring as a result of ranching and farming activity on 700 million acres of the semiarid Great Plains of the United States and Canada.

In particular, erosion is reducing the organic matter and plant nutrient contents of range and cropland. The research project will therefore seek to evaluate organic matter and soil fertility resources of the area, and to determine how these resources are distributed in

Above left: Biological technician Terry E. Welch (left) and physical science technician Steven D. Corbin take light penetration readings to measure light available for photosynthesis at various depths in a pond. (0583X496-10)

Above: Corbin (left) and ecologist Charles M. Cooper section a pond bottom core as part of a study of the sedimentation history of a pond. (0583X497-7)

major soil groups that developed under differing parent materials, climatic regimes, and vegetation successions.

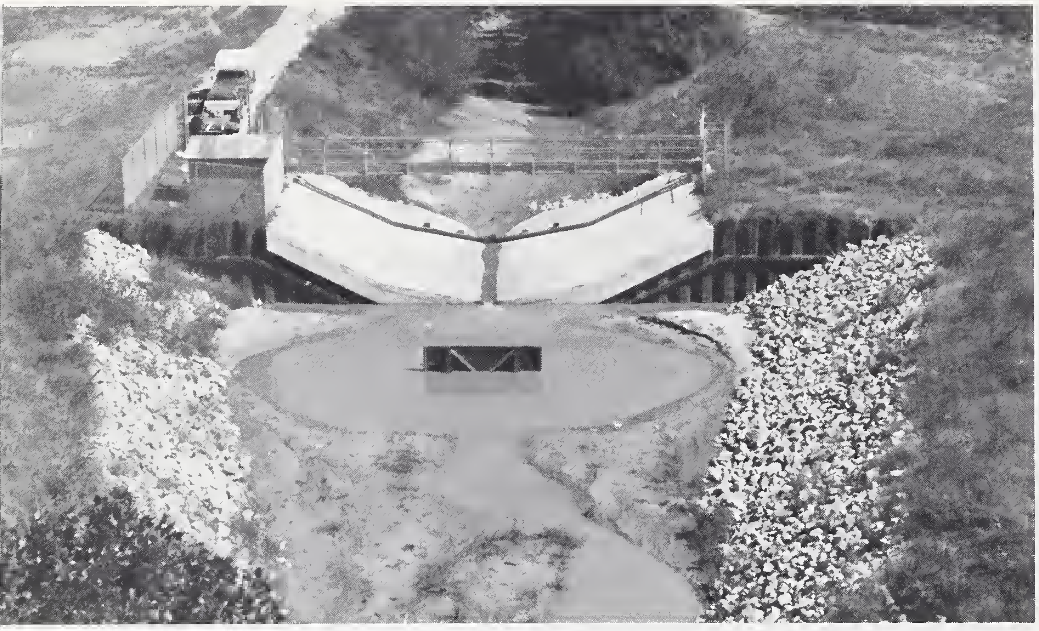
A major research effort to address the sedimentation problems caused by farming in the Southern United States is headquartered at the ARS Sedimentation Laboratory in Oxford, Miss. There, engineers, soil chemists, physicists, biologists, and other water specialists are studying the mineral composition and the structural features of soils in an effort to find those properties associated with high erodibility. At the same time, specialists in cropping practices are searching for ways to cultivate productive yet quite erodible soils with only a minimum of topsoil loss.

Sedimentation Laboratory director Neil L. Coleman believes conservation tillage to be one of the best ways to control erosion. This kind of tillage leaves residue from a previous crop on the land among the plants of a new crop.

One of the most promising practices might be double cropping winter wheat and soybeans. A field of winter wheat could be planted to be harvested in spring. Wheat stubble would be left in the field. Soybeans would then be planted in the wheat stubble by drilling without plowing. In this way, the disturbance and loosening of the soil, which aid erosion, are kept to a minimum, and the soil is enriched by the nitrogen-fixing action of the soybeans.

As part of the ongoing national effort to improve and maintain water quality, biologists and water quality specialists at the Oxford laboratory are constantly monitoring aquatic ecological systems to counteract the adverse effects of runoff from agricultural land.

Concentration of *Escherichia coli* (*E. coli*) fecal bacteria in the bottom sediments of streams is sometimes 2 to 760 times greater than concentrations in the water itself. Unless microorganisms in the sediment of stream bottoms are taken into consideration, stream water quality evaluation results are misleading. *E. coli* readily attach themselves to sediment particles, and streambeds can be good environments for bacterial growth. Any disturbance stirs the sediment and resuspends the bacteria in the water. This increases pollution and lowers water quality. With this in mind, sediment samples from streambeds—as well as routine surface water samples—are evaluated



Measurements made at the critical-flow sediment and water measuring on Goodwin Creek Watershed, Miss., help scientists evaluate the design of streambank reclamation projects upstream. A scale model of the flume is shown in the cover photo. (PN-7052)

in stream water quality studies.

Even under the best conditions, rainfall loosens soil particles, sand grains, and other sediment materials and moves them from upland soils downslope with runoff water. As this runoff water proceeds downslope, it forms a network of eroded channels of progressively increasing size. These are called rills and gullies and they combine to form small upland streams which, in turn, join to form larger streams and rivers. Once begun, this natural drainage pattern evolves to carry increasingly large amounts of sediment. Hydraulic engineers at the Sedimentation Laboratory examine the motion of water and sediment in drainage channels to determine ways to prevent cropland from being destroyed by rills and gullies or lost in large masses by collapsing streambanks.

On upland fields, terraces and other means of drainage control are being

Putting Down Roots

Engineers are evaluating a variety of grasses, shrubs, and trees, both alone and in combination with structural materials, to determine the best ways of establishing and maintaining plants for effective erosion control on streambanks.

"Bank erosion has reached acute stages in many sections of the country," says Andrew J. Bowie, a hydraulic engineer at the ARS Sedimentation Laboratory, Oxford, Miss. He estimates that the 300,000 miles of eroding streambanks in the United States produce approximately 500 million tons of sediment each year.

Effective structural streambank protection has been costly to install and maintain. In a report to the Secretary of the Army by the Chief of Engineers, it was estimated preventive treatment for 148,000 miles of seriously eroding streambanks would cost about $420 million a year. This indicates that treatment of many areas suffering damage cannot be economically justified unless the newer, more effective methods under study are initiated.

"Practical criteria are urgently needed by conservationists and engineers so they can effectively incorporate vegetative erosion control measures as integral parts of channel planning design," Bowie says.

"Our research will determine, first, the maximum flow velocities that various plants can withstand along the bank boundary, with different soil types and degrees of bank slope; second, the vegetative and structural designs that are most economically effective in terms of durability and initial cost; and third, the establishment and maintenance requirements for controlling growth and stream encroachment.

"Preliminary studies for the northern Mississippi area indicate that native species of both grassy and woody plants are preferable to imported

Before stabilization with vegetation, the banks of Johnson Creek in northern Mississippi were ready to collapse, destroying valuable adjacent farmland. (PN-7053)

used to slow the flow of runoff water and to reduce the amount of sediment eroded and carried to rivers.

In streams, either vegetative or structural means are being designed to prevent banks from collapsing (see "Putting Down Roots," in box below). Hydraulic engineers at the Sedimentation Laboratory design and build models of their concepts to determine their effectiveness before the structures are actually built. Several kinds of effective, yet inexpensive grade control structures designed at the laboratory are now widely used throughout the United States.

Because fluid mechanics processes control the transportation and deposition of sediment and chemical pollutants in rivers, streams, and lakes, the laboratory has indoor facilities for studying how water flows and moves sediments.

Such experiments include investigations of sediment and chemical pollutant diffusion processes, the mechanics of sediment suspension, the effects of turbulence in fluid flow, and the effect of forces exerted by streamflow on individual streambed particles. They also include many other fluid mechanics problems that are of direct importance to understanding and controlling topsoil loss, herbicide, insecticide, and sediment transport, and stream channel protection and control.

The knowledge and methods developed by ARS researchers in Colorado and Mississippi for controlling and reducing sedimentation are far-reaching. They serve as a scientific base for action agencies, such as the Soil Conservation Service, which advises farmers on developing comprehensive soil conservation plans, and the U.S. Army Corps of Engineers and the Bureau of Reclamation, which maintain and protect streams and rivers for navigation, sediment transport capability, and wildlife habitat.

In a new and potentially profitable development, research knowledge is also being used in computer projection models that will help in the wide-scale planning of agricultural activities.

In these models, data from agricultural conditions and cultural practices can be utilized. Based on correct real-life measurements, such as that from the Sedimentation Laboratory, the models will produce a number of projected results that can be examined for their desirability and potential economic benefits. Once this information is in the hands of U.S. farmers and ranchers, they will be better able to manage the Nation's resource heritage wisely.

Neil L. Coleman is located at the USDA Sedimentation Laboratory, P.O. BOX 1157, Oxford, Miss. 38655.—(By Neal Duncan, New Orleans, La.) ■

varieties," Bowie says. "Sprigging is better than seeding for crown vetch and ivies. Good stands of most grasses are obtained by seeding. Native black willow (*Salix nigra*) appears to be superior to the hybrid varieties of willow in both survival and growth. River birch (*Betula nigra*) shows some potential when planted under the right environment. The shrubs, indigo bush and bristly locust, also respond quite well," he says.

Studies are continuing for a more complete evaluation of the vegetative treatments. A more detailed report of plant establishment will be possible after one or two more growing seasons, but an evaluation of survival rates and erosion control effectiveness will require even more time. No stabilization program, regardless of how well designed, will remain effective, however, without maintenance, Bowie stresses.

Structures installed in conjunction with vegetative plantings may deteriorate in time or become ineffective because of changes in physical characteristics of the stream. Plant cover is subject to change from destructive physical forces and through natural laws of plant succession. Too much plant growth can reduce channel capacity.

Periodic onsite appraisal of the channel condition is necessary to detect possible weak points and to schedule maintenance and repairs before potential problems reach the acute stage. Determination of an effective maintenance program is necessary to prolong the useful life of stabilization measures and safeguard banks against possible erosion in the future.

Andrew J. Bowie is located at the USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.—(By Neal Duncan, New Orleans, La.) ■

Hydraulic engineer Andrew J. Bowie inspects the same stretch of creek after vegetation and rocks were used to stabilize the banks. (0583X500-5)

Remaking the Good Earth

A typical stripmine on the Northern Great Plains. The five "windrows" on the left are overburden removed by dragline to reveal the coal seam on right. (0878X941-20)

Currently, some form of surface mining—for coal, sand and gravel, or minerals—occurs in all 50 States. Surface mining provides over half of this country's coal.

More than 10 million acres (4 million hectares) of land in 28 States contain coal deposits that lie close enough to the Earth's surface to be stripmined. Major deposits of strippable coal are found in the Northern Great Plains, and in the Western States and Alaska.

Most mined lands are used for agricultural purposes before surface mining and will ultimately be returned to that use.

To reclaim surface-mined land for agriculture requires restoring the soil's chemical, physical, and biological properties. If topsoil is not replaced, organic matter will be low. Merely stockpiling topsoil may disturb soil properties and contribute especially to the loss of organic matter. The latter is probably least disturbed when the topsoil is removed as a single layer, without disturbing its profile, and replaced in the same condition.

After the coal is removed, the reclamation process is really quite straightforward. The overburden or spoil (the material over the coal deposit) is replaced and the land contoured, attempting to recreate the original topography. Next, subsoil and topsoil are returned. Fertilizing and replanting are the final steps.

Above: At the Energy Fuels Mine near Steamboat Springs, Colo., range scientist William McGinnies and range technician Paula Nicholas evaluate midsummer growth of several grass species planted on reclaimed land. (0778X905-13A)

However, it may take several years—from the beginning of the mining process until vegetation is restored—to fully reclaim a surface-mined area. The three main problems are attaining the desirable level of soil fertility and stability, and achieving proper hydrologic properties. Through research on faster and more productive revegetation, ARS scientists are trying to quicken the reclamation process and solve these three problems.

In the West, ARS scientists are testing grasses, forbs, and shrubs to find out which grow best under certain conditions. They measured the direct effect of the thickness of the returned topsoil on plant growth—both above and below ground.

Near Steamboat Springs, Colo., range scientist William J. McGinnies and range technician Paula J. Nicholas evaluated a mixture of 16 grasses, 8 forbs, and 8 shrubs at a work site with depths of topsoil ranging from zero to 18 inches.

"The greater the topsoil depth—at least up to 18 inches—the denser the stand of seeded plants and the greater the herbage production," says McGinnies, who works at Fort Collins, Colo.

By the second year, the rating of stand (out of a possible 100 percent) was 16 percent for plots without topsoil, to 50 percent for plots with 18 inches of topsoil. However, many species failed to become established. Subsequent greenhouse tests showed that intermediate wheatgrass, Russian wildrye, and hard, Arizona, and tall fescues looked promising for use as stabilizing vegetation.

"Depth of topsoil and species selection should be considered for highest success in reclaiming stripmined lands in the Central Rocky Mountains. Species can be selected that will provide high root production in topsoil, good rooting into underlying spoil, maximum herbage yield or a combination of these. Because a single species seldom possesses all these characteristics, a mixture of species will probably be best for revegetating disturbed lands," says McGinnies.

With the increase in stripmining in the West, more areas are being found that contain high levels of acidic material in the overburden. Previously, this was a problem mainly for Eastern and Central coal regions.

The primary source of the acid is naturally occurring iron sulfide, which, when exposed to air, oxidizes much faster than when buried. Spoil can be too acidic for plant growth after it has

Reza Khanbilivardi, water resource engineer at Pennsylvania State University, watches as a precision plotter, linked to a computer programmed with erosion measurements from the field, creates a 'three-dimensional" diagram of erosion. (0583W523-31)

been moved for stripmining operations.

Soil scientists Ernest M. Taylor and Gerald E. Schuman say both lime (calcium carbonate), a mineral found in many parts of the United States, or flyash, a waste product collected by electrostatic precipitators atop coal-burning power generating plants, can be mixed with acidic mine spoils to lower the acid level. These materials produce a more favorable growing medium for plants and result in more successful revegetation. Adding either 4 or 8 inches of topsoil that has been saved before mining also results in better plant growth.

Taylor and Schuman, at the High Plains Grasslands Research Station, Cheyenne, Wyo., applied the equivalent of up to 80 tons per acre of lime or 40 tons per acre of flyash in greenhouse studies. The application rates required under field conditions have not yet been determined.

In the Northern Great Plains, an area with some of the Nation's largest coal reserves, ARS researchers have been working with North Dakota coal companies on stripmined sites for several years. They have collected data on the depth of stripped soil that needs to be returned; the crop-producing potential when sripped soil is replaced over high-sodium, impermeable clay spoils; and types of crops that grow best on reclaimed land.

Although surface mining has been going on for many years in the Eastern United States, little beyond individual observation has been known about what happens to water runoff, soil erosion, and groundwater during and after mining activities, says C. R. Amerman, hydraulic engineer and coordinator of a multiagency study on the impact of surface mining and water quality at ARS's North Appalachian Experimental Watershed, Coshocton, Ohio.

Although the short time allotted for data collection in the premining and postmining periods limits the study, there are some meaningful results, according to Amerman.

"In general, the study shows that in comparison to premining conditions, surface mining will produce more surface runoff, may produce higher mineral concentrations in the runoff water, and groundwater may drop to a lower level and may be higher in minerals. However, our preliminary results show that good reclamation practices can control runoff and reduce soil loss to near premining levels as soon as good vegetative cover is reestablished on the watershed," Amerman says.

"The results from analyses of groundwater were more critical," Amerman says. "Because the mining operations break up and fragment the rock layers between the surface and the coal layers being mined, water flowing down through the mine spoil is exposed to more rock surface and, therefore, dissolves more minerals. Samples taken from test wells showed iron, manganese, and sulfate levels exceeded drinking water standards."

However, Amerman adds that before it would be possible to evaluate the long-term impact of surface mining and reclamation on hydrology and water quality, it would be necessary to collect data for several years until the new, postmining, ecological equilibrium was reached.

Besides field and laboratory tests, ARS researchers at University park, Pa., are programming mathematical models into a computer to find out how acid and salt move through reclaimed minespoils, how much erosion occurs on acid and salty land sites, how surface treatments like terracing affects erosion and water quality, and how chemicals are transported and interact in water.

Soil scientist Andrew Rogowski at the Northeast Watershed Research Center says, "Our computer model will predict ways to lower stripmine pollution from the erosion of stripmine spoils and improve land reclamation after mining is over."

The model was developed in response to a 1979 law intended to prevent or minimize acid mine pollution and to restore stripped areas to as near original condition as possible. Rogowski says the model will provide two services toward upholding the law. First, mine operators will be able to predict, based on scientific information, the postmining condition of the land. Second, during the mining operation, operators will be more knowledgeable concerning ways to avoid unnecessary pollution and circumstances that may hinder reclamation.

Natural conditions programmed into the model are precipitation data, runoff patterns and rates, temperatures, elevations, slope angles, soil types, compaction, and soil textures and soil aggregate-size distribution.

Other USDA agencies are also working with States and with local conservation districts (or their State associations) on new or improved plant materials for reclaiming mined lands. Many joint research projects between ARS, Soil Conservation Service, Forest Service, and Economic Research Service (ERS), the U.S. Environmental Protection Agency, the U.S. Department of Interior's Bureau of Land Management, and State universities are solving various problems dealing with reclaiming stripmined lands.

—(Compiled by Henry Becker III, from information provided by Dennis Senft, Oakland, Calif., Ray Pierce, Peoria, Ill., and Stephen Berberich, Beltsville, Md.) ■

Cranberry Girdlers Eat Trees, Too

James A. Kamm (left), ARS entomologist, and Paul Morgan, plant pathologist with the Dwight Phillips Oregon State Nursery, Elkton, Oreg., examine Douglas fir nursery seedlings for cranberry girdler damage. (0283X133-34A)

Above: Graders at the Dwight Phillips Oregon State Nursery size Douglas fir trees and cull out girdler-damaged or diseased seedlings before they are packaged for shipment. (0283X134-26)

Right: The taproot will die if cranberry girdlers eat the bark off all the way around it. Killed taproots never regrow; instead, branch roots form and take up the function of absorbing water and nutrients. (0283X133-30)

Nursery yields of Douglas fir seedlings may increase as much as 18 percent now that seedling damage—long attributed by the timber industry to the root weevil—has been identified as the work of the cranberry girdler, a notorious pest of cranberries and grasses (see *Agricultural Research*, June 1980, p.14).

Pheromone traps monitoring cranberry girdler populations showed that the girdlers migrate into nurseries from adjoining grass fields or fields cropped to other host plants. Once in a nursery, moths lay eggs and the resulting larvae feed on tap roots, reducing seedling quality and vigor, and in some extreme cases, killing the seedlings.

"Cranberry girdlers don't particularly like Douglas fir seedlings, but once they are in a nursery, they stay and feed there," says ARS entomologist James A. Kamm, Corvallis, Oreg., who along with chemist Leslie M.

Cranberry girdler larvae weaken Douglas fir seedlings by eating the bark off the taproot; they do not damage leaves or stems. (0283X135-24A)

McDonough, Yakima, Wash., developed the pheromone traps.

Only a few girdlers need be in a nursery before treatment is required, says Kamm, who cooperated again with McDonough and researchers with the Oregon Department of Forestry and the Weyerhauser Corporation, to determine the extent of the problem and identify control measures.

It was found that in addition to Douglas fir, all true fir species are damaged by girdler larvae, but the larvae do not feed on pine, cedar, hemlock, or spruce.

The girdler problem can be practically eliminated by applying diazinon to nurseries during the flight period of the moths—usually from mid-June to early July—followed by one or two applications of chlorpyrifos to control any larvae.

Where possible, grasslands bordering a nursery should be reseeded to a nonhost crop to reduce migration of adults into the nursery. Removing weeds—especially grass weeds—from a nursery and planting a nonhost cover crop in vacant beds also helps.

Using pheromone traps to detect infestations can help in deciding when control treatments are necessary.

James A. Kamm is located in Rm. 2048-B, Cordley Hall, Oregon State University, Corvallis, Oreg. Leslie M. McDonough is located at the Yakima Agricultural Research Laboratory, 3706 Nob Hill Blvd., Yakima, Wash. 98902.—(By Lynn Yarris, Oakland, Calif.) ■

Pesticide Runoff Study Completed

A recently completed 4-year study shows that the highest loss of pesticide in runoff water occurred, as might be expected, when herbicides were applied directly in the irrigation water.

William F. Spencer, ARS bioscientist at Riverside, Calif., sampled surface irrigation runoff water following the application of 18 pesticides to large fields in California's Imperial Valley. Crops included in the study were cotton, sugarbeets, alfalfa, lettuce, onions, and melons.

Pesticides applied directly to the soil were found in runoff in higher amounts than those that were aerially applied, except where the aerial applications coincided with the irrigation application.

Concentrations were highest in the first irrigation following pesticide application, and the longer the time between pesticide application and the first irrigation, the less pesticide was found in runoff water.

Total amounts of each pesticide removed from treated fields were calculated from runoff water volumes and pesticide concentrations.

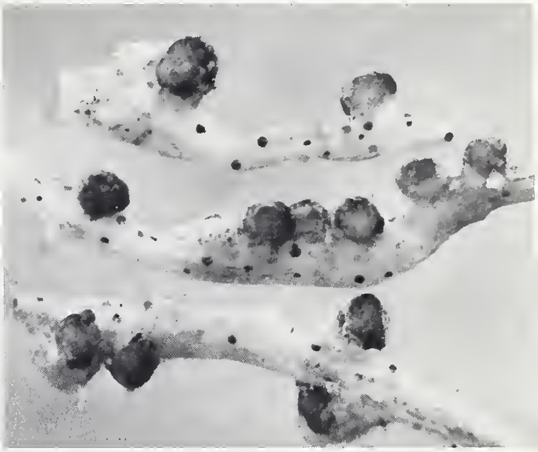
Spencer says the concentrations and total amounts of pesticides in runoff water are dependent upon the characteristics of the pesticides, their methods and rates of application, the time elapsed between application and the first irrigation, the number of irrigations since the pesticide application, and irrigation efficiency.

William F. Spencer is located at the Soils and Environmental Science Department, University of California, Riverside, Calif. 92521.—(By Paul Dean, Oakland, Calif.) ■

Another Nematode Is Found

A new nematode species that attacks potatoes has been identified in the Pacific Northwest and growers in the area with this problem may have to change their crop rotation practices.

Columbia root-knot nematode (*Meloidogyne chitwoodi*) is the name of the new pest, and the nematologists who discovered it are John H. O'Bannon, ARS, and Gerald S. Santo, Washington State University, both at Prosser, Wash.



Photomicrograph of potato roots showing egg masses of Columbia root-knot nematodes. Each egg sac, which may contain over 200 eggs, covers the female's body. The female herself measures only 6/10ths of a millimeter in length. (PN-7051)

The discovery is the result of an investigation triggered by reports of severe nematode damage to several potato fields in 1978 and 1979 that did not fit the pattern expected from the Northwest's traditional nematode potato pest, the Northern root-knot nematode. Damaged potatoes were found along the Snake River in Idaho, and in Washington and Oregon. Recently, the Columbia root-knot nematode has been found in northern California and Nevada.

Growers in these States routinely rotate potatoes with wheat to control the Northern root-knot nematode. Studies have shown, however, that wheat is a prime host for the Columbia root-knot nematode and growers with this pest should probably rotate to alfalfa instead. Since alfalfa is a host plant for the Northern root-knot nematode, Northwest growers should check their fields for both nematode species.

Other hosts that have been identified for Columbia root-knot nematodes are corn, oats, barley, sugarbeets, and tomatoes. Symptoms of infestations in these hosts and in wheat, however, are not always evident. New bioassays to assess soil for Columbia root-knot presence will have to be developed.

Though the damage to potatoes caused by the two nematode species is

U.S. Government Printing Office
Public Documents Department
Washington, D.C. 20402
Official Business

Postage and Fees Paid
U.S. Department
of Agriculture

G—95

the same—galls or lumps on the surface of tubers and internal brown spots—Columbia root-knot nematodes may infest tubers more rapidly. Yields are not affected too much but quality is severely reduced; tubers get downgraded and are ruined for the processing market.

Early indications are that the new nematode is much more aggressive in its ability to invade and reproduce at lower temperatures than the Northern root-knot nematode.

Fumigation treatments that have been used successfully on Northern root-knot nematodes have not been as effective on Columbia root-knot nematodes. Studies are being continued to learn more about this new pest.

John H. O'Bannon is located at the Irrigated Agriculture Research and Extension Center, P.O. Box 30, Prosser, Wash. 99350.—(By Lynn Yarris, Oakland, Calif.) ■

Ozone Tolerance of Pines

Scotch pine and jack pine were the most susceptible of nine pine species exposed to ozone treatments during 70 days of tests at the Nursery Crops Research Laboratory, Delaware, Ohio.

Alden M. Townsend, ARS research geneticist, and Leon S. Dochinger, research plant pathologist with the U.S. Forest Service, fumigated 2-year-old pine seedlings at 0.1, 0.2, and 0.3 ppm levels of ozone concentration. They observed immediate effects and evaluated the trees for long-term damage the following growing season.

The pine species tested were southwestern white, Scotch, eastern white, bristlecone, ponderosa, Austrian, Japanese black, jack, and Japanese white.

Scotch pine was the only species that showed serious injury at the 0.1 ppm concentration. At 0.2 and 0.3 ppm, Scotch, Japanese white, jack and ponderosa were most susceptible to injury, Townsend says.

The most tolerant pines were eastern white and bristlecone, which showed little or no injury at the 0.3 ppm level. Austrian, southwestern white and Japanese black pines were also fairly tolerant, he says.

The first symptoms observed on the susceptible species were yellowing of the needle tips and mottling caused by small areas of dead cells. Later, yellowing spread throughout the seedling's foliage.

Evaluation the following year showed Scotch pine seedlings exposed to ozone concentrations of 0.2 or 0.3 ppm survived at a 43-percent rate compared to untreated seedlings, which had a 100-percent survival rate.

Jack pines showed a pronounced response to different ozone rates. None survived when exposed to 0.3 ppm, whereas the 0.2 ppm level had no significant effect on survival, Townsend says.

The other seven pine species did not show a significant decrease in survival rate compared to seedlings not exposed to ozone treatment.

The ozone levels used in the tests are often found along heavily traveled roads and in large cities, Townsend says. Ozone concentrations of 0.3 ppm are not uncommon in areas of heavy auto traffic.

Townsend suggests that homeowners avoid planting pines near roads where they could be exposed to both ozone and deicing salts. If they do plant pines in exposed areas, they should select tolerant species.

Alden M. Townsend is located at the Nursery Crops Research Laboratory, 359 Main Rd., Delaware, Ohio 43015.—(By Ray Pierce, Peoria, Ill.) ■